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IS THE ELECTRONIC THEORY OF
MATTER LEGITIMATE?

Electrons, or the Nature and Properties of Negative Electricity. By Sir Oliver Lodge, F.R.S. Pp. xv+230. (London: George Bell and Sons, 1906.) Price 6s. net.

AT the present time there are few more absorbing topics among physicists and chemists than the electron and its relation to matter, and none on which a more complete mystification exists. A book on the subject by so illuminating and inspiring a publicist as Sir Oliver Lodge is therefore doubly acceptable at the present time.

A few words on the existing situation may be of general interest. It will be recalled that the researches in optics on the one hand, culminating in the discovery and elucidation of the Zeeman effect, and in the phenomena of the Crookes's tube on the other, resulting in the isolation of the free electron and the measurement of its constants by J. J. Thomson, made the scientific world familiar with the conclusion that the same electron or atom of negative electricity is an ultimate constituent of all atoms, and possesses, in virtue of the magnetic field it creates in motion, inertia which, though small, is definite and indistinguishable in ordinary circumstances from the inertia possessed by ordinary matter. There is little that would to-day be generally considered as controversial in these two conclusions. On the contrary, the researches which have led to them have received the unstinted admiration of all. But upon these conclusions are based others, concerned, not with the nature of electricity, but of matter, in the highest degree controversial and speculative, which regard the electron as the universal unit out of which all matter is essentially built up, and mass as an electromagnetic phenomenon due to a vast assemblage of constituent electrons grouped together in stable configurations constituting the atoms. This view of atomic structure was developed by J. J. Thomson in two papers (*Phil. Mag.*, December, 1903, and March, 1904). He regarded the atom as composed of a uniform sphere of positive electrification containing an electrically equivalent number of electrons revolving in regular motion about the centre, and showed that according to the numbers of the electrons periodic sequences of properties of the systems would occur strikingly similar to the periodic sequences in the properties of the atoms of the actual elements themselves.

One of the most enthusiastic supporters of the universal extension of the electronic theory to explain the properties of matter has been Sir Oliver Lodge himself, who saw in the instability, natural to a system constituted of electrons in constrained motion, due to the external radiation of energy that must be supposed to take place, a possible cause of radioactivity and of the observed disintegration of the radioactive elements. Some few months ago, however,

J. J. Thomson (*Phil. Mag.*, June, 1906) published the results of an investigation into the actual number of electrons existing in an atom of matter by three independent methods, which led to the uniform and unexpected conclusion that the number of electrons is of the same order as the weight of the atom in terms of that of hydrogen as unity. Since then it may be safely said that no one has known quite what to think with regard to the electronic theory in its application to material phenomena, and the present book, from the pen of a writer to whom so often in the past the student has looked for light and leading in difficult places, will therefore be opened with curiosity and read with eagerness.

The effect of the profound changes which have come over the subject in the last few months is evident in the preface, where we read:—

"A proof that the atom of matter is essentially composed of such electrons, and that its mass, too, is of purely electromagnetic nature, is lacking; the electromagnetic theory of Matter . . . must be regarded for the present as no better than a working hypothesis. It is a hypothesis of stimulating character, and of great probability, but its truth is still an open question that is probably not going to be speedily closed."

The extract may be said to give the keynote to the treatment in the book. It is evident that the writer himself has not lost confidence in the ultimate triumph of the electron theory in its universal aspect, and although he is aware of, and does not attempt to minimise the magnitude of, the recent difficulties which have arisen, his enthusiasm is still undamped. In a chapter towards the end of the book, devoted to a consideration of some of these difficulties, he himself describes the recent paper of J. J. Thomson, to which reference has been made, as "the most serious blow yet dealt at the theory, at least in its simpler and cruder form" (p. 194); and again (p. 151), "it has tended to reduce the whole subject to a state of exaggerated uncertainty." But his final conclusion is (p. 200):—

"The most exciting part of the whole is the explanation of matter in terms of electricity, the view that electricity is, after all, the fundamental substance, and that what we have been accustomed to regard as an indivisible atom of matter is built up out of it; that all atoms—atoms of all sorts of substances—are built up of the same thing. . . . But it must be remembered that although this solution is strongly suggested it is not yet a completed proof. Much more work remains to be done before we are certain that mass is due to electric nuclei."

No excuse need be offered for dwelling on this side of the book, for the attitude of the leading exponents to the recent developments of the electronic theory of matter is topically the most interesting to the scientific reader at the moment. But attention must not on that account be diverted from what is, after all, the main subject of the book, not the nature of matter, but that of electricity. The major part is devoted to an admirable and inspiring treatment of those solid results of experiment and analysis elucidating the nature and properties of negative electricity,

which have led to the establishment on a firm basis of the atomic theory of electricity. It is only the last third which is devoted to the speculative and controversial side in which the electron becomes also a material conception replacing the "*urstoff*" or "protyle" of earlier similar speculations. Some of the points touched upon in the text are treated at greater length in a series of appendices, but no index has been furnished, which is a decided omission.

Of the chapters presenting special features of interest may be mentioned chapter ix., which is largely concerned with the size of the electron and its power of penetrating matter, the effects of a collision between electron and atom, and the ratio of the distribution of the energy of collision between heat and X-rays; chapter xi., which deals with the magnetism of light, and affords a very clear exposition of the nature of the action, which "has opened up a new branch of physics, a new department, as it were, of atomic astronomy, with atoms and electrons instead of planets and satellites"; and chapter xiv., which contains a full treatment of the experimental work of Kaufmann on the high-velocity β -ray electrons expelled by radium. In chapter xv. no less than five alternative views of the constitution of the atom are considered, which emphasises, to use the author's own expression, the "painfully indefinite character" of the theory applied to matter. Exception must be taken to chapter xviii., entitled "Summary of other Consequences of the Electron Theory," which begins with a section headed "Radio-activity" (!). Now this is surely unfair to a great and independent experimental subject, because not only has radio-activity taught us something really definite and fundamental about matter as distinguished from electricity, but also it has at the same time furnished, for example, in the penetrating power of the α and β rays, the most damaging evidence against the possibility of an electronic constitution of matter.

Sir Oliver Lodge's well-known forceful and attractive style is always in its element in dealing with the conquests achieved in physical science, but the concluding passage is something of the nature of a parting shot at the reader.

"Especially must the inner ethereal meaning both of positive and negative charges be explained: whether on the notion of a right-and-left-handed self-locked intrinsic wrench-strain in a Kelvin gyrostatically-stable ether, elaborated by Larmor, or on some hitherto unimagined plan. And this will entail a quantity of exploring mathematical work of the highest order."

To explore the inner ethereal meaning of this right-and-left-hander elaborated by the author demands a brain of unquestionable gyrostatic stability.

Having dealt with the author's book as the exposition of his views of the nature of electricity and matter, and having first fully acknowledged the debt the reading public owe to Sir Oliver Lodge for the leading part he has taken in the public work of advancing and expounding the new doctrines, it may not be considered ungracious to touch a little less enthusiastically than the author does on certain as-

pects of the new theories themselves here so powerfully advocated.

Without in the least wishing to minimise the importance of the part played by imagination and hypothesis in experimental science, the question may fairly be asked whether these persistent efforts to "simplify" matter and reduce it to a single fundamental existence have a place in the legitimate scientific thought of the present day, or whether they are not a continually recurring phase of an apparently innate primitive mental aspiration, the origin of which is to be sought, not in the phenomena themselves, but in the predilections of the human brain. The rule that where one conception suffices, it is superfluous to use more than one may be fully granted. But it is surely still something of a mental luxury to believe that these ideas of the essential unity of matter and its ultimate reducibility to a single type, which exist deep down in the most ancient mythologies, and may be said to form part of the common stock of original ways of thinking, have as yet any other than this foundation. Matter continues to be experimentally incomprehensible, and as recent work in radio-activity has shown, the possibilities of its complexity are far from exhausted by the eighty or more recognised elements. The attempts, for example Prout's hypothesis, to reduce matter to one common basis testify rather to the aspiration for that kind of explanation which to our ideas seems appropriate. It is undoubtedly satisfying to picture all matter as built up of some one unit, because an ingrained bias exists in the mind towards the simplest possible origin of phenomena. There is, however, evidence that our natural subjective impressions of what is fit and appropriate are, when they are traced to their source, derived in the first place from an insufficient study of the operations of Nature, which fuller knowledge usually dispels. It is, of course, possible that with the even fuller knowledge of the future some such doctrine as a connection between what is mentally harmonious and what is physically true may transpire, and the doctrine find a legitimate place in the theories of pure physics. But for the present the supporters of the electronic theory of matter have to show that they have not allowed their enthusiasm to betray them into an attitude of mind which belongs rather to the past than to the future of scientific thought.

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THE COLONISATION OF VIRGINIA.

The Generall Historie of Virginia, New England, and the Summer Isles, together with the True Travels, Adventures and Observations, and a Sea Grammar. By Captaine John Smith. Two vols. Vol. i., pp. xxxiii+396; vol. ii., pp. xix+330. (Glasgow: James Maclehose & Sons; London: Macmillan and Co., Ltd. 1907.) Price 25s. net.

AT the time of writing (April) the warships of the Powers are gathered together in Hampton Roads to honour the tercentenary of the founding of the Commonwealth of Virginia, and the Jamestown Exposition (held at Norfolk) will soon be opened for